IEC 61850 - The Impact on Testing

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Summary

The application of IEC 61850 [1] introduces several new issues for testing substation devices. The most obvious change is the different way of "wiring" to obtain the signals. But there are other issues that change the way of testing, such as configuration. Signals and data traffic of different nature have to be regarded, such as real time peer-to-peer messaging (GOOSE), digitized data from CTs and VTs (sampled values), and client/server communication for SCADA purposes. The availability of machine readable, system wide configuration information opens new aspects for an extended testing scope (system testing).

The IEC 61850 Engineering Concept and Testing

More than just defining a set of services and communication protocols, IEC 61850 also specifies a common, vendor independent configuration concept. Machine readable configuration information in a standardized format (Substation Configuration Language - SCL) is used in this process.

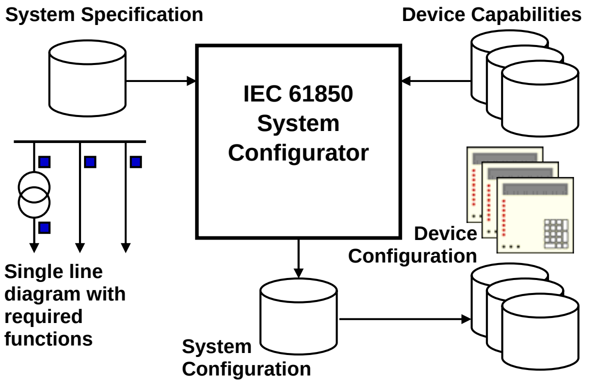

Figure 1 *Engineering Concept*

This approach opens enormous potential for cost savings in the engineering. Beyond this, it enables new, automated procedures for the configuration of tests.

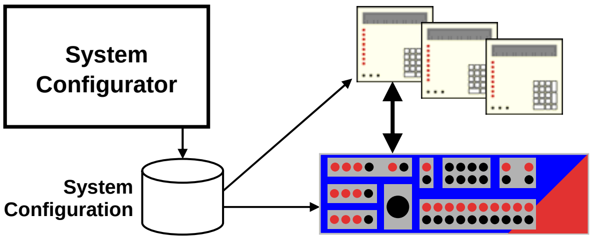

Figure 2 *Usage of configuration information for testing*

GOOSE

In "classical technology", the data exchange between the substation devices on the bay level was established by hard-wired connections between binary outputs and binary inputs of the devices. This was a very costly solution. The number of I/Os was limited to the available terminals, tons of copper wires had to be laid, the testing of the wire loops was a nightmare, and a change of a configuration a real threat.

With IEC 61850, this becomes replaced by the GOOSE mechanism. The real-time telegrams are sent over the common substation networks and the data from each sender (publisher) can be made available to any receiver (subscriber). A sturdy repetition scheme provides fast signaling, high reliability, and even a kind of "wire break supervision". The number of possible I/O points with GOOSE is very much extended and a change of the system configuration is performed through the engineering process by reconfiguring the devices without using any screwdriver.

Of course, modern test equipment must be able to connect to these GOOSE messages. The feedback from and stimulus to the devices under test that was formerly exchanged via binary I/Os, must now be established by "wiring" the test equipment to the substation network.

Sampled Values

In a similar way as the (mostly binary) status information is transformed into data on the substation network, IEC 6150 specifies this as well for the instantaneous voltage and current values delivered by the VTs and CTs. These data are called "Sampled Values". A so-called "merging unit" (MU) collects the signals from the sensors and merges the digitized values into a data stream published in the substation network. This way, measured values (e.g. the bus voltage for a busbar protection scheme) can be easily distributed to multiple bay devices. Known issues from classical wiring, like the burden of the wire loops, do no longer occur with this new technology.

A test equipment must be able to simulate merging units by publishing Sampled Values to be subscribed by the devices under test.

Functional Testing of Protection

By "wiring" protective relays and test sets through the substation network, the test configuration is just transformed into the networked world.

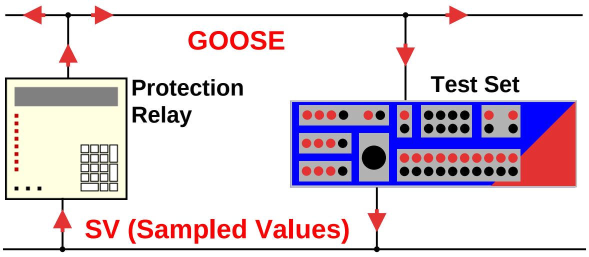

Figure 3 *"Fully networked" protection testing*

Looking at classical testing of protection functions, the world appears not to have changed very much. Regarding the scope of test usually performed until now, this is true. The protection functions of the relays still work in the same way. E.g. testing a distance protection will be performed by using the exact same fault scenarios and assessment criteria as before. For an effective use of existing knowledge minimized training efforts to adopt to the new situation, it is important that a test system preserves the working environment from classical testing and allows the re-use of existing test procedures for use with IEC 61850.
Of course, the standardized configuration information significantly facilitates the test setup. Where wiring plans had to be investigated and test leads had to be manually connected to banana plugs in the past, many aspects of the test configuration can be efficiently supported by using the substation configuration data.

Client/Server SCADA Communication

The substation devices provide a lot of additional information to be used for SCADA purposes. These data had been never exchanged with the peer devices on the bay level and that were commonly not available for testing. Using these data during testing was usually out of scope, since the access was provided through many different, vendor specific methods.
With IEC 61850, these data are all served in a standardized way. A tester may look up some status data (e.g. special pick-up information) by using a common tool for all relays. This will provide extended depth of testing. Also, the protection engineers will be able to assess many issues of the SCADA communication, which were formerly in the responsibility of the communication engineers.

System Testing

System testing up to different levels was and is already so performed. Prominent examples are the End-to-End tests for sophisticated line protection schemes. Now, with the availability of substation wide configuration data, the feasibility of tests involving more devices is very much facilitated. Test with multiple points of test signal injection and measurement of response will become more easily to implement in IEC 61850 installations. Beyond the capability to be simply connected to the substation network, test sets used in such applications need to have the ability to perform coordinated and precisely synchronized tasks as a part of distributed, system wide test system. The ongoing progress of the technology prepares the ground for such system in the near future.

Literature

[1] IEC 61850-1:2003 Communication Networks and Systems in Substations; Introduction and Overview

About the Authors

Fred Steinhauser was born in Feldkirch, Austria, in 1960. He studied Electrical Engineering at the Technical University of Vienna, where he obtained his diploma in 1986 and received a Dr. of Technical Sciences in 1991.
In 1998 he joined OMICRON, where he worked on several aspects of testing power system protection. Since 2000 he works as a product manager with a focus on substation communication issues. Fred Steinhauser is a representative of OMICRON in the UCA International Users Group. He is member of WG10 and WG17 in the TC57 of the IEC working on the standard IEC 61850, and a member of CIGRÉ SC B5.

Thomas Schossig (IEEE) was born Gotha, Germany, in 1970. He received his diploma (master degree) in Electrical Engineering at the Technical University of Ilmenau (Germany) in 1998. He worked as a project engineer for control systems and as a team leader for protective relaying at VA TECH SAT in Germany from 1998 until 2005. Now he is working as a product manager for substation communication products at OMICRON electronics in Austria since the beginning of 2006.